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IEA HIA Task 37 - Hydrogen Safety

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Den danske brint- og brændselscelledag 2016

IEA HIA Task 37
Hydrogen Safety

Categories

Program EUDP
Fælles overordnet teknologiområde - Brint og brændselsceller
Projekttype Forskning - Journalnummer 64014-0534

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Keynumbers

Periode: 4/2015 - 3/2018
Egen finansiering: 0,03 mio.
Støtteprocent: 90%

Bevillingsår: 2014
Støttebeløb: 0,30 mio.
Projektbudget: 0,33 mio.

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Term: 2015-2018
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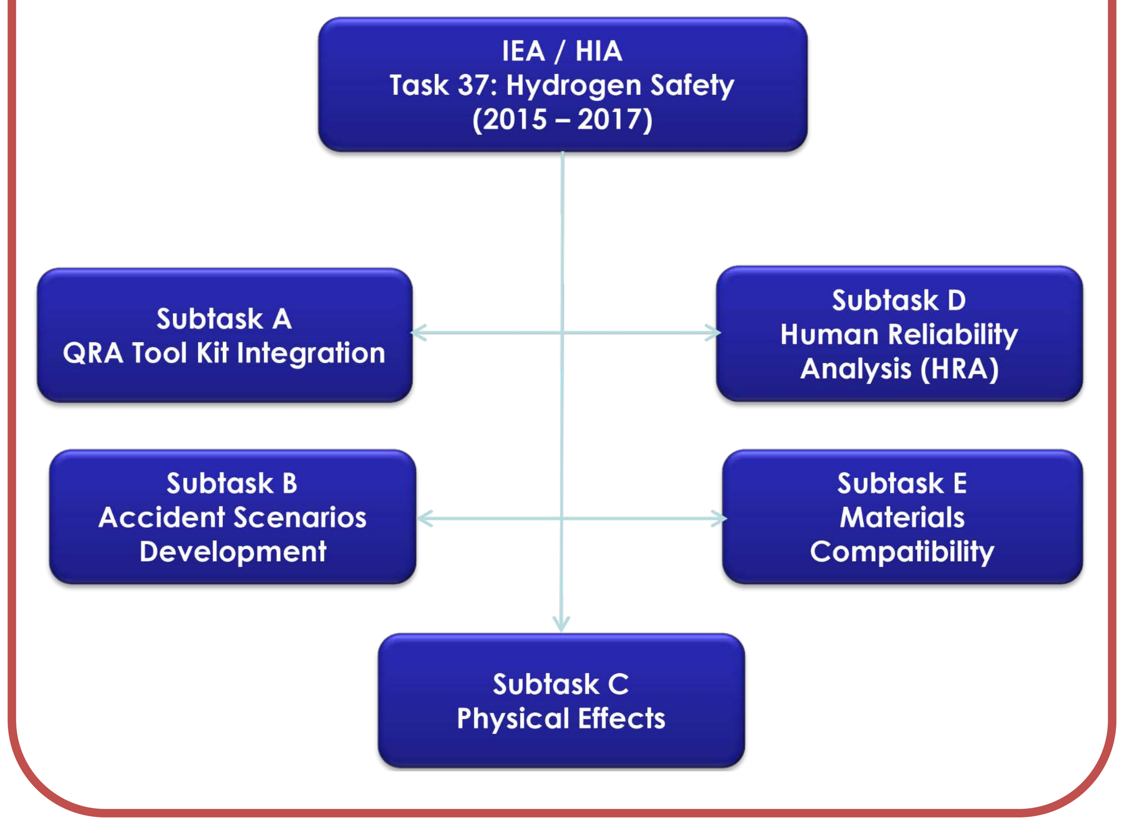
Project details

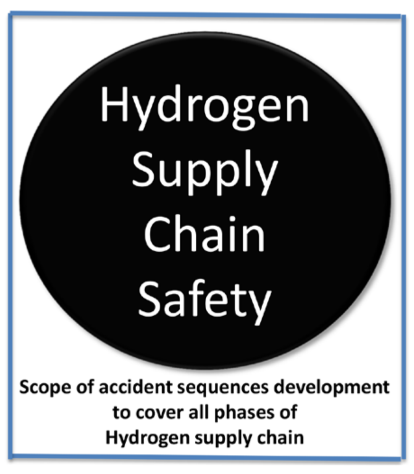


Partners

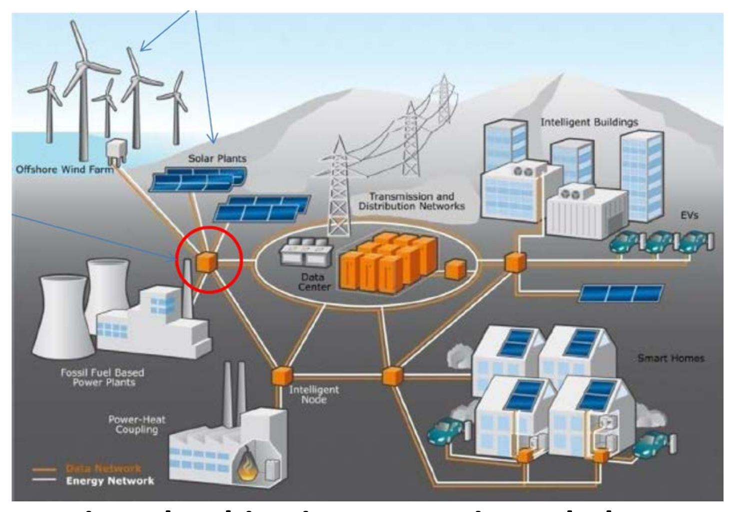
1. United Technologies Research Center (UTRC) USA
2. National Renewable Energy Laboratory (NREL) USA
3. Department of Energy (DOE) USA
4. Sandia National Laboratories (SNL) USA
5. HySafe Canada
6. Technova Inc Japan
7. Karlsruhe Institute of Technology (KIT) Germany
8. Federal Institute Materials Research and Testing, BAM Germany
9. University of Ulster UK
10. Health & Safety Laboratory (HSL) UK
11. University of Warwick UK
12. Air Liquide France
13. INERIS France
14. Technical University of Denmark (DTU) Denmark
15. University of Pisa (UniPi) Italy
16. Tecnalia Spain
17. EC Joint Research Center European Commission (EC)
18. GexCon Norway
19. University College of South East Norway Norway

Work plan / objective / goals

The work plan and objectives of this task are designed to support the acceleration of safe implementation of hydrogen infrastructure through coordinated international collaborations and hydrogen safety knowledge dissemination.



- Development of a hydrogen safety integration model (or tool):
  A user-friendly integrated hydrogen safety model (tool) that facilitates system analysis and determines appropriate risk metrics.
- Development of risk management strategies to ensure safety implementation of hydrogen infrastructure:
  To provide a systematic approach to determine gaps in current basic and applied research.
- Collection of systems, subsystems, and components reliability (i.e., field failure) data and human error (HE) probabilities (i.e., human factors) to support quantitative risk analysis (QRA):
  To collect information on effects of components failures on hydrogen systems and infrastructure
- Performance of consequence analysis to facilitate the accelerated adoption of hydrogen technologies.



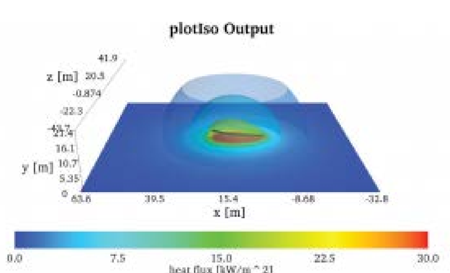
The above-mentioned objectives are intended to support the overarching goal of enhancing safe implementation of hydrogen-based technologie.

Progress/results

HyRAM toolkit developped by Sandia National Laboratories.

- A tool to do probabilistic risk assessment using fault and event trees as well as state-of-the –art consequence models.
- The HyRAM toolkit integrates state-of-the-art models and data for assessing hydrogen safety.

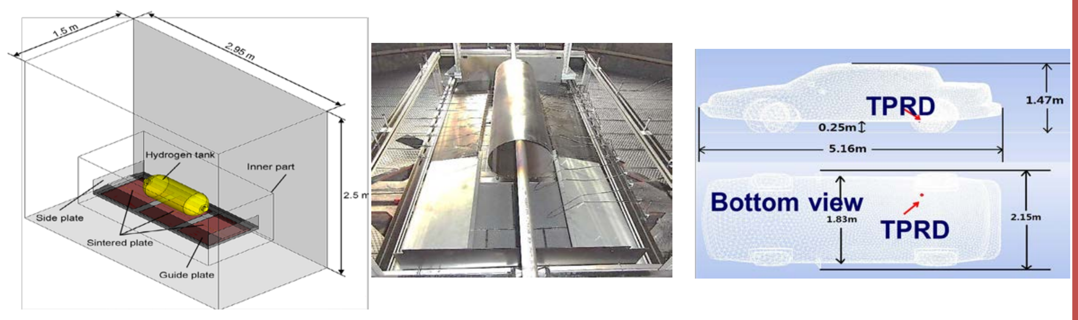
HyRAM provides a common platform for stakeholders conducting quantitative risk assessment and consequence analysis for hydrogen systems. The resulting information provides the scientific basis to ensure code requirements are consistent, logical, and defensible.



Scenario	End State Type	Avg. Events/Year
100pct Release	No Ignition	0.0008
10pct Release	No Ignition	0.0012
1pct Release	No Ignition	0.0015
0.1pct Release	No Ignition	0.0050
0.01pct Release	No Ignition	0.0348

Lit.: http://hyram.sandia.gov; Katrina M. Groth and Ethan S. Hecht. HyRAM: A methodology and toolkit for Quantitative Risk Assessment of Hydrogen Systems In Proceedings of the International Conference on Hydrogen Safety (ICHS 2015), Yokohama, Japan, October 19-21, 2015

BONFIRE tests and simulation by K.I.T. and University Ulster



- Modelling heat radiation essentially affects the fire resistance rating (FRR) of a bare hydrogen tank in bonfire test simulations
- The use of resins with different T_d for CFRP tank jackets can result in drastic difference in FRR.
- Burner has a significant influence on the FRR. Burner(s) should be standardised.
- Heat release rate affects FRR for the same design burner. HRR should be standardised.
- The current GTR fire test protocol can result in incomparable results of the same storage tank in different laboratories around the globe.

Lit.: V. Molkov; Progress in physical effects at Ulster, presentation April 20th ,2015 IEA HIA Task37, Karlsruhe (ulster.ac.uk)

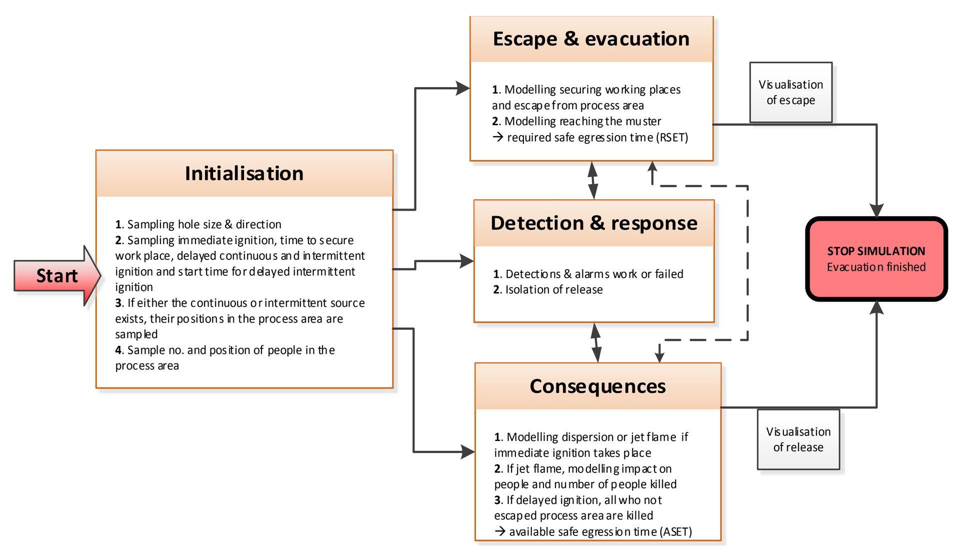
Next steps

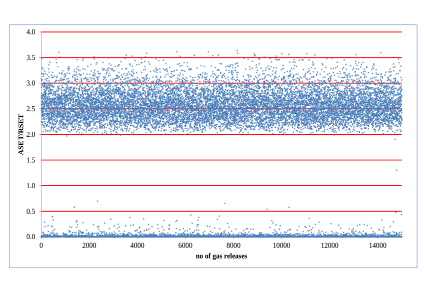
A number of other tools and outputs resulting form the activities in the sub-tasks as indicated in the orgainsational scheme are under development. Hereunder, a tool under development by DTU to integrate Human error into QRA calculations:

Integration of human behavior / errors into a dynamic model of a hydrogen installation.

Monte Carlo approach enables to model and simulate many more hazard scenarios including the effects of insufficient maintenance of e.g. detectors and evacuation. This enables to predict worst case scenarios opposite to the worst case assumptions made by risk experts.

- Event sequences are simulated in parallel.
- Dynamic interaction of events
- Events taking place in one sequence change the conditions in the other sequences
- Data are sampled statistically,
- e.g. hole size, wind speed, number and position workers
- Multiple runs (many!) are performed to extract risk numbers (IR, PLL, group risk)
- Individual scenarios can be simulated graphically (animation)





Ratio of Available vs. Required Safe Egress Times ASET/ RSET. Values above 1 indicate safe egress conditions. Each point represent a specific scenario.

Lit.: F. Markert, I. Kozine, N. J. Duijm; process Risk Assessment using Dynamic Simulation of Scenarios; Chemical Engineering Transactions; 48 (2016); ISBN 978-88-95608-39-6

Conclusion and perspectives

The task 37 supports a transition to a new HYDROGEN ECONOMY. The work is a continuation of IEA HIA tasks 19 and 32. The consortium has close relationships to the International Association HySafe and to the standardization activities according to TC197.

- build–up of new safe and sustainable infrastructure e.g. for safe hydrogen delivery from production site to refueling stations
- Safe use of hydrogen in various kinds of applications
- Safety standards for garages, car parks, tunnels etc..

The goal is to support an inherently safer approach to build the future hydrogen energy infrastructure in Denmark and internationally.

The hydrogen infrastructure may:

- Integrate energy supply and fuel supply infrastructures energy sector and transport sector
- New hydrogen applications will develope through time, as e.g. hydrogen trains as alternative for diesel trains on tracks were electrification is too expensive, e.g.:

A passenger train connecting two towns in Germany is the first in the country to run on hydrogen. The train will begin operation in December 2017, and will run between Buxtehude, a small city, and the beach town Cuxhaven. Three other German states have also expressed interest in adopting similar projects.
The Coradia iLint passenger train, built by Alstom in France and revealed this month, uses hydrogen recycled from the chemical industry to travel 497 miles on one charge. It can run up to 87 miles per hour, storing any excess energy in Lithium batteries slung on the bottom of the train car.

(https://www.manufacturing.net/news/2016/09/germanys-first-hydrogen-train-uses-recycled-fuel)